Closing the Gaps – Taking into Account the Effects of Heat Stress and Fatigue Modeling in an Operational Analysis

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ABSTRACT

Traditional, combat model based analysis of Dismounted Combatant Operations (DCO) has focused on the 'lethal' aspects in an engagement, and to a limited extent the environment in which the engagement takes place. These are however only two of the factors that should be taken into account when conducting an operational analysis. Analyses of DCO especially need to take the human factors, such as emotion, cognition, sociality and physiology into account in order to provide comprehensive analysis and soldier-system focused input to military decision makers.

Only recently has heat stress and fatigue modelling become possible when conducting research wargaming, due to the advances in science and improved modelling capabilities. The study presented in this paper looks at the possible changes to research wargaming outcomes when modelling heat stress within a combat situation.

The study is based on a modelled attack into a defended building by soldiers bearing full personal protection equipment (PPE) and a typical combat load of weapon, ammunition, water and other required kit. The attack is modelled to be occurring in hot (above 45 degrees Celsius) dry conditions against a defender that does not possess any PPE and carries far less equipment. The "objective" of the study is to determine the relative combat effectiveness of different section sizes versus a standard opponent using specified measures of effectiveness. The attack is conducted under two different modelling environments using the same combat model. The first ignores the heat stress and fatigue caused by the PPE and equipment weight, the second causes the soldier's performance to degrade as their core body temperature rises and they become fatigued. The combat effectiveness ranks of the section size options are developed under both environments and compared to determine what, if any, affect the human factors had on the relative combat effectiveness of the different section sizes.

Further strengthening the links between operational analysts and human factors scientists, in order to provide military decision makers with solid operational analyses is vital to the success of future military operations. This collaborative Canadian/Dutch study on heat stress modelling illustrates the need and the challenges ahead.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **OCT 2010**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **Closing the Gaps Taking into Account the Effects of Heat Stress and Fatigue Modeling in an Operational Analysis**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Land Forces Operational Research Team DRDC CORA 6th Floor Maj General Pearkes Building 101 Col By Drive Ottawa, Ontario K1A 0K2 CANADA**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADA564696. Human Modelling for Military Application (Applications militaires de la modelisation humaine). RTO-MP-HFM-202**		

14. ABSTRACT

Traditional, combat model based analysis of Dismounted Combatant Operations (DCO) has focused on the lethal aspects in an engagement, and to a limited extent the environment in which the engagement takes place. These are however only two of the factors that should be taken into account when conducting an operational analysis. Analyses of DCO especially need to take the human factors, such as emotion, cognition, sociality and physiology into account in order to provide comprehensive analysis and soldier-system focused input to military decision makers. Only recently has heat stress and fatigue modelling become possible when conducting research wargaming, due to the advances in science and improved modelling capabilities. The study presented in this paper looks at the possible changes to research wargaming outcomes when modelling heat stress within a combat situation. The study is based on a modelled attack into a defended building by soldiers bearing full personal protection equipment (PPE) and a typical combat load of weapon, ammunition, water and other required kit. The attack is modelled to be occurring in hot (above 45 degrees Celsius) dry conditions against a defender that does not possess any PPE and carries far less equipment. The objective of the study is to determine the relative combat effectiveness of different section sizes versus a standard opponent using specified measures of effectiveness. The attack is conducted under two different modelling environments using the same combat model. The first ignores the heat stress and fatigue caused by the PPE and equipment weight, the second causes the soldiers performance to degrade as their core body temperature rises and they become fatigued. The combat effectiveness ranks of the section size options are developed under both environments and compared to determine what, if any, affect the human factors had on the relative combat effectiveness of the different section sizes. Further strengthening the links between operational analysts and human factors scientists, in order to provide military decision makers with solid operational analyses is vital to the success of future military operations. This collaborative Canadian/Dutch study on heat stress modelling illustrates the need and the challenges ahead.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**SAR**	**18**	

1.0 INTRODUCTION

Traditional, combat-model-based analysis of Dismounted Combatant Operations (DCO) has focused on the 'lethal' aspects in an engagement, and to a limited extent the environment in which the engagement takes place. These are however only two of the factors that should be taken into account when conducting an operational analysis. Analyses of DCO especially need to take the human factors, such as emotion, cognition, sociality and physiology into account in order to provide comprehensive analysis and soldier-system focused input to military decision makers. This is also important in view of the increasing interest in unmanned ground vehicles to serve the needs of dismounted soldiers. Without the ability to accurately model human performance in military activities as it declines due to human factors, it will be very difficult for researchers to estimate the full benefits of unmanned vehicles. This paper examined the potential of one combat model to include the effects of heat stress on dismounted soldiers and the influence that including this factor had on the outcome of the study.

2.0 THE PROBLEM

Figure 1 displays the complexity facing researchers attempting to include human factors within combat modelling. Quantifying the relationship between the cause (soldier load) and the tertiary effect of reduced combat effectiveness is very much in the initial stages of human factors research. In the Netherlands, TNO has built a model called SCOPE [1] while in the USA the Natick Soldier Centre and the Army Materiel Systems Analysis Agency has developed the Infantry Warrior Simulation (IWARS). Both models present promising early steps to addressing the needs of the research community and the military.

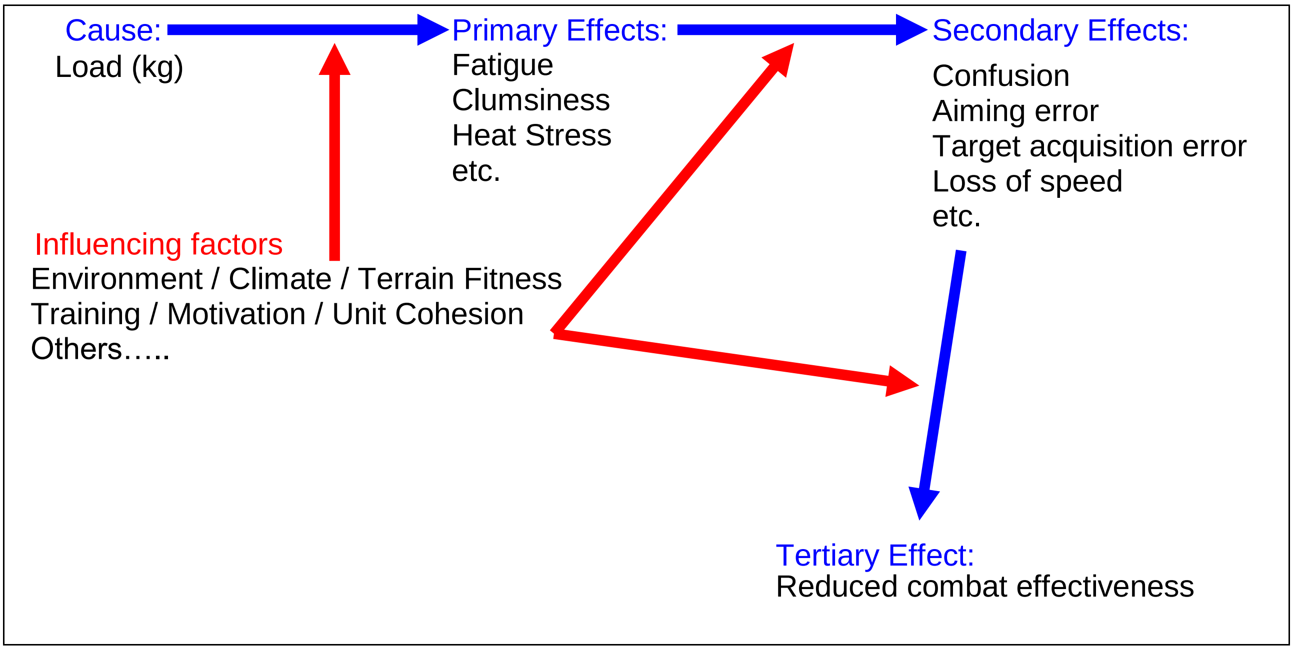


Figure 1: Soldier Load & Combat Effectiveness.

Soldiers carry their loads in order to acquire specific and important capabilities. Figure 2 displays the dilemma faced by current commanders when deciding the amount of equipment that their soldiers must carry into any emergent situation. Combat modelling that accurately represents the trade off between load, capability and human limitations would be invaluable to DCO commanders at every level and at all stages of the army's acquisition to employment chain. In Figure 2, the plus signs indicate a positive relationship between the origin of the arrow (the cause) and the termination of the arrow (the effect). For the influencing factors, no sign is indicated as they may be either positive or negative influences on the relationship between cause and effect. In other words they may enhance the effect or dampen it. A soldier's load increases capabilities while at the same time increasing weight to be carried. The increased capabilities contribute to increased combat effectiveness. The weight of the load increases the fatigue felt by the soldiers, bulky loads increase clumsiness and in hot climates load adds to heat stress. These effects contribute to increased confusion, target acquisition errors, aiming errors and increased loss of speed as soldiers tire more quickly under their burdens. Confusion, target acquisition error, aiming error and lack of speed all degrade the combat effectiveness of a soldier and the unit. The key question to be researched is what is the optimal load for a soldier and when does the weight of an extra piece of kit cause more problems than the solutions that the extra capability provides are worth?

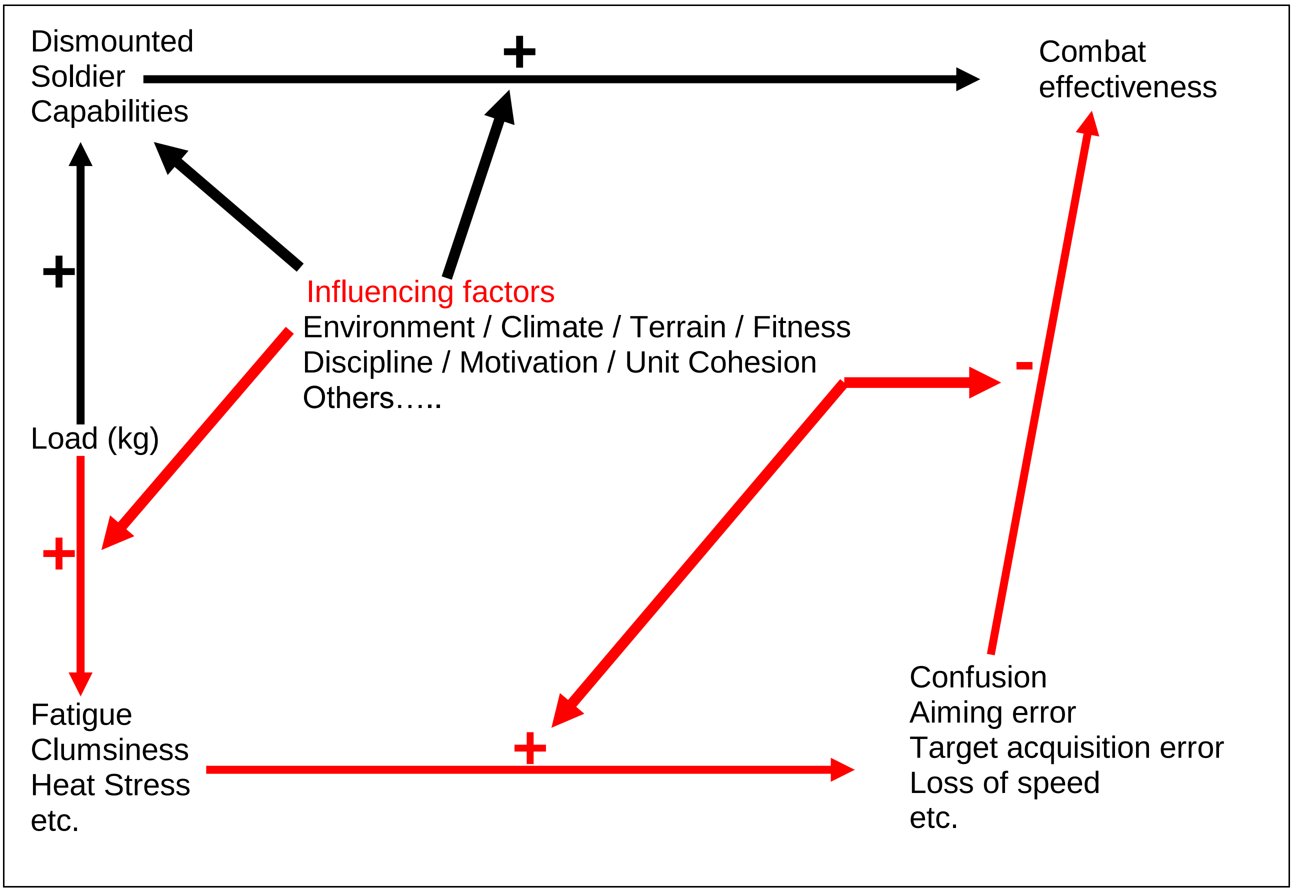
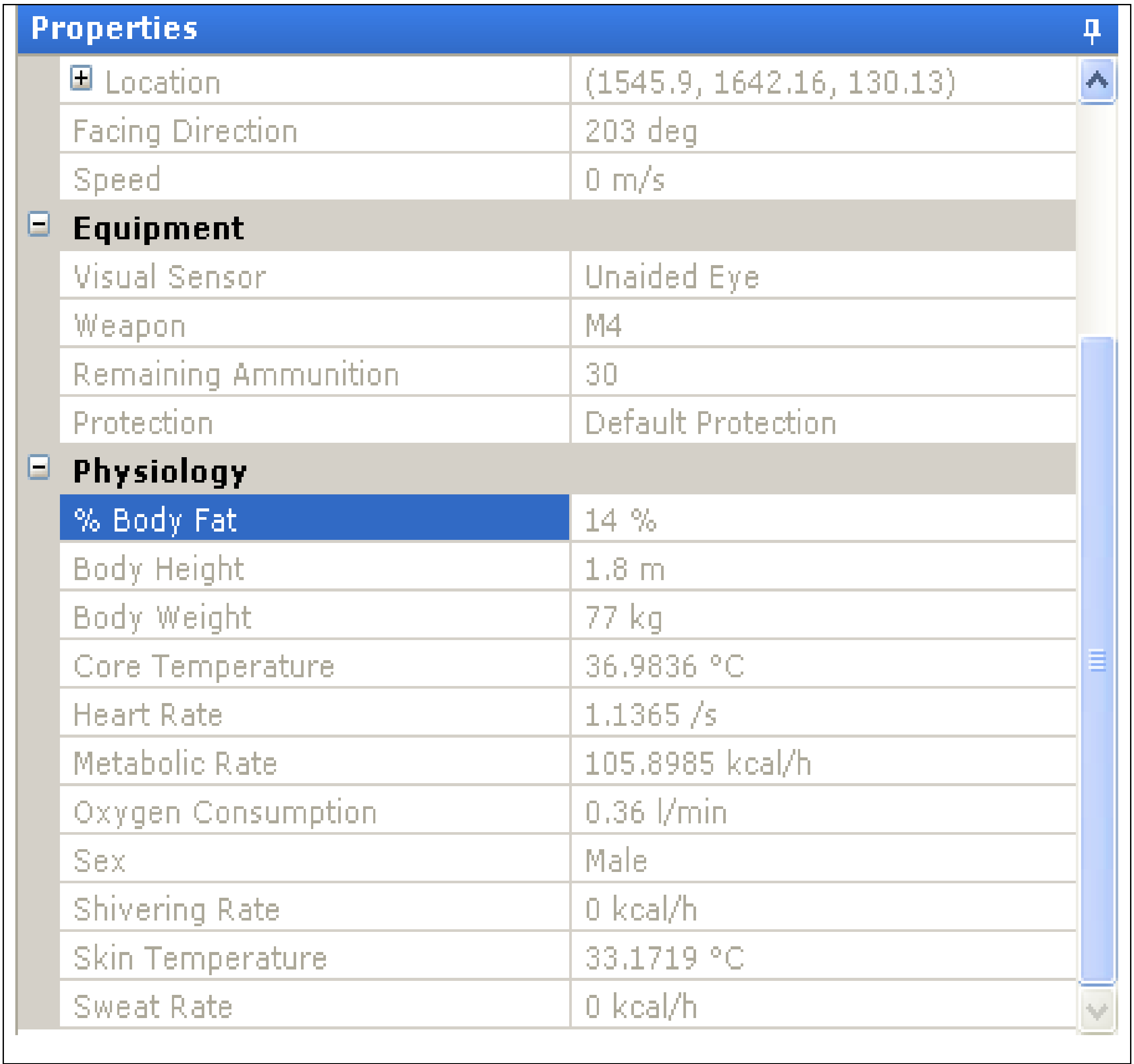


Figure 2: Dismounted Soldier Load, Capabilities & Effectiveness.

3.0 MODELLING THE EFFECTS OF HEAT STRESS

Only recently has heat stress and fatigue modelling become possible when conducting research wargaming, due to the advances in science and improved modelling capabilities. The collaborative

Canadian/Dutch study presented in this paper looked at the possible changes to research wargaming outcomes when modelling these human factors to a certain level within a combat situation. The combat model used for the study was IWARS, which monitored soldiers' core body temperatures (CBT) as the simulation progressed. For the equipment that a soldier carried, IWARS had data on weight and thermal retention. The more equipment carried, the faster a soldier's CBT will rise given the same level of activity. The ambient temperature of the environment is also a factor in the soldier's heat stress. IWARS allowed the researcher to preset a CBT threshold that forces a soldier to change or even cease activity once it is reached. Allowing the user to define the heat stress threshold was useful given the uncertainty surrounding a soldier's vulnerability to heat stress. Further complicating the modelling effort was the high degree of uncertainty about what constitutes a normal core body temperature [2]. For this study, normal CBT was set at 36.89 degrees Celsius for the soldiers. Two heat stress thresholds were applied, the first was 38.5 degrees Celsius and the second was 37.2 degrees Celsius. Soldiers whose CBT hit the threshold were rendered combat ineffective for the remainder of the game. Figure 3 displays the data available for a soldier modelled in IWARS. Note that the game had been in progress for some time when this screen shot was taken as indicated by the elevated Core Temperature.



Properties	
Location	(1545.9, 1642.16, 130.13)
Facing Direction	203 deg
Speed	0 m/s
Equipment	
Visual Sensor	Unaided Eye
Weapon	M4
Remaining Ammunition	30
Protection	Default Protection
Physiology	
% Body Fat	14 %
Body Height	1.8 m
Body Weight	77 kg
Core Temperature	36.9836 °C
Heart Rate	1.1365 /s
Metabolic Rate	105.8985 kcal/h
Oxygen Consumption	0.36 l/min
Sex	Male
Shivering Rate	0 kcal/h
Skin Temperature	33.1719 °C
Sweat Rate	0 kcal/h

Figure 3: Reporting a Soldier's Vital Signs in IWARS.

4.0 APPROACH

The study was based on a modelled attack into a series of defended buildings by soldiers bearing full personal protection equipment (PPE) and a typical combat load of weapon, ammunition, water and other required kit. The attack was modelled to be occurring in hot (above 45 degrees Celsius) dry conditions against a defender that did not possess any PPE and carried far less equipment. The nominal "objective" of the study was to determine the relative combat effectiveness of different section sizes versus a standard opponent using specified measures of effectiveness. The attack was conducted under two different modelling environments using the same combat model. The first ignored the heat stress caused by the PPE and equipment weight, the second caused the BLUE force soldiers to stop once their CBT hit the designated threshold. Two different thresholds were used resulting in three different conditions for the assessment of the section sizes. The combat effectiveness ranks of the section size options were developed under all three conditions and compared to determine what, if any, affect the human factor had on the relative combat effectiveness of the different section sizes.

The BLUE force consisted of 12 soldiers organized three different ways, 2 sections of 6 soldiers (2X6), 3 sections of 4 soldiers (3X4) and 6 sections of 2 soldiers (6X2). The defending RED force consisted of 3 sections of 2 soldiers with the sections spread out across different buildings within the objective. BLUE sections attacked one at a time and had to stop once half their strength was down for any reason (kinetic or heat stress). The BLUE force could only continue if one whole RED section was eliminated. A BLUE engineer performed wall breaching to allow the BLUE force to avoid using obvious entrances such as doors and windows.

Each section size participated in 30 attacks under each of three conditions. Some games produced inconclusive results due to the engineer dying during the game. The engineer's role was to create a series of openings in the building walls for the remaining BLUE force to enter the defended area. The engineer was not expected to come under RED fire during the game. If the engineer died the BLUE team had no orders to find an alternate route into the compound. Unfortunately the engineer was occasionally a victim of the charges used to create a hole in a wall. When the engineer died the BLUE force became stranded after the last breach. The results from these inconclusive games were not used in the analysis. The valid game results are provided in Annex A. Figure 4 depicts an image of the IWARS game.

Figure 4: A Scene from IWARS.

5.0 MEASURES OF EFFECTIVENESS

Only one measure of effectiveness (MOE) was used to rank the options in the study. Mission Success was a compound measure built from BLUE and RED residual combat strength (RCS) and whether or not BLUE accomplished its mission to clear the objective. This prevented a costly victory (in terms of BLUE losses) from scoring as well as one that did not cost the lives of as many BLUE soldiers. A victory point (VP) scorecard was established that penalized BLUE for falling below threshold RCS values but provided higher scores for reducing the RED force to below the same or lower threshold RCS values. BLUE lost more points for falling below a threshold than they gained for forcing RED below the same threshold, in other words BLUE lives lost cost more than the gain from killing RED. Table 1 displays the VP scores for each categorized RCS outcome of the games.

Table 1: Mission Success Definitions and Victory Scores.

		BLUE RCS			
		>= 0.66	0.33 < 0.66	<= 0.33	0.0
RED RCS	>= 0.66	Indecisive / Continue Score = 15	Partial RED Victory Score = 9	Full RED Victory Score = 4	Full RED Victory Score = 0
	0.33 < 0.66	Partial BLUE Victory Score = 20	Indecisive Score = 13	Partial RED Victory Score = 7	Full RED Victory Score = 2
	<= 0.33	Full BLUE Victory Score = 24	Partial BLUE Victory Score = 16	Indecisive Score = 9	Partial RED Victory Score = 3
	0.0	Full BLUE Victory Score = 27	Full BLUE Victory Score = 18	Partial BLUE Victory Score = 10	Stop Score = 3

The outcome of BLUE's mission was added into the victory score in the following manner: Once BLUE's RCS column had been determined; the column was shifted one to the right if BLUE had not cleared the objective. If BLUE had cleared the objective the column was shifted one to the left. Table 2 displays the full range of VP scores possible using the blended MOE. Note that the "Bonus" and "Penalty" columns have been added to allow for the adjustment due to BLUE mission outcomes.

Table 2: Mission Success Definitions and Victory Scores.

	Bonus	Blue @ >= 0.66	Blue @ 0.33 < 0.66	Blue @ <= 0.33	Blue @ 0	Penalty
Red @ >= 0.66	22	15	9	4	0	-3
Red @ 0.33 < 0.66	28	20	13	7	2	-2
Red @ <= 0.33	33	24	16	9	3	-1
Red @ 0	37	27	18	10	3	-1

The intersection of the adjusted column and the row corresponding to the RED RCS contained the VP score for the game. As an example, at the end of a game BLUE had cleared the objective and in the process lost six of twelve soldiers while eliminating the RED force entirely. BLUE RCS was 0.5, RED RCS was 0 and the mission outcome was a win for BLUE. Based solely on the RCS levels, the VP score was 18. Due to BLUE achieving its objective, the final VP score for the game was 27. Had BLUE failed to clear the objective the VP score would have been 10. Note that due to the requirement for a section to stop once half its members were down, BLUE could completely eliminate RED, still have effective soldiers and yet lose the game due to not achieving the objective.

6.0 RESULTS

6.1 No Heat Stress Study

The initial runs of the game imposed no performance penalty on the soldiers from heat stress. All of the three options examined demonstrated significant dominance over the defending RED forces. Each option averaged at least 25 VP and the 6X2 option averaged over 35. The difference between the 6X2 structure and the other two (2X6 and 3X4) was statistically significantly different at 95% confidence level using a Kruskal-Wallace test for differences between means. Figure 5 displays the results for the No Heat Stress stage of the study. Had the study terminated there, and had a recommendation been made based on the No Heat Stress results, the 6X2 structure (in green) would have been the option recommended over the other two in yellow.

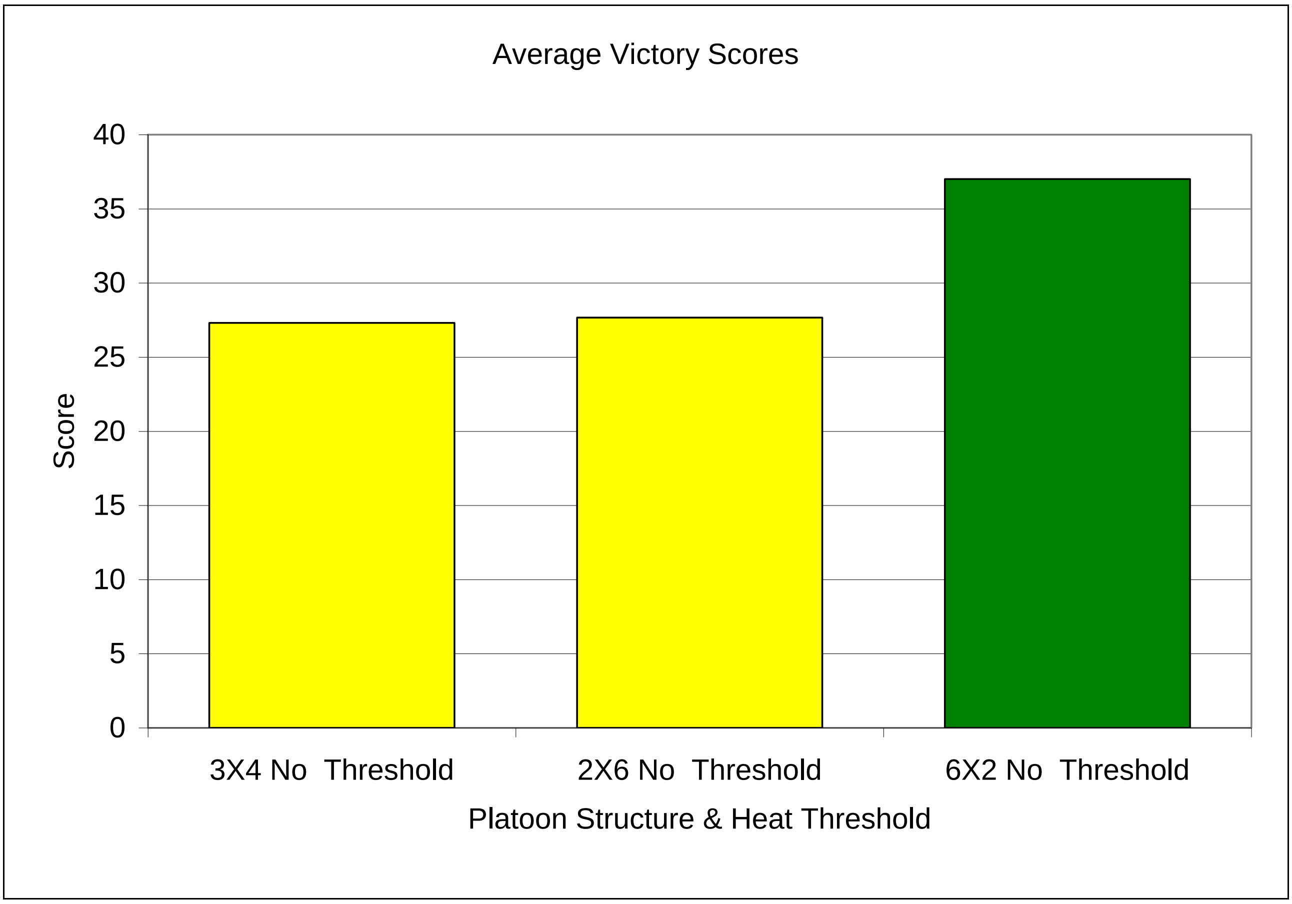


Figure 5: Rank Orders Based on No Heat Stress Games.

6.2 38.5 Degrees Celsius Heat Stress Threshold Study

The games were then re-run while applying a threshold of CBT reaching 38.5 degrees Celsius before the soldier shut down and became ineffective for the remainder of the game. Figure 6 displays the rank orders derived from this stage of the study. The red coloration of the 2X6 structure indicates its score was statistically significantly lower than the 6X2 structure. While the order has shifted and the three options produced a wider range of results, the differences between the three options were entirely the product of soldiers killed in action, not heat stress losses. In fact heat stress losses were not a significant factor in any of the game outcomes. This may have been due to the game's short duration. The soldiers generally weren't active long enough to become heat stressed using the 38.5 threshold.

That the outcomes for this phase were different from the outcomes for the first phase spoke to the degree of variability inherent to the game. More runs of the game would have produced more stable and reliable data, however time did not permit more runs for this study.

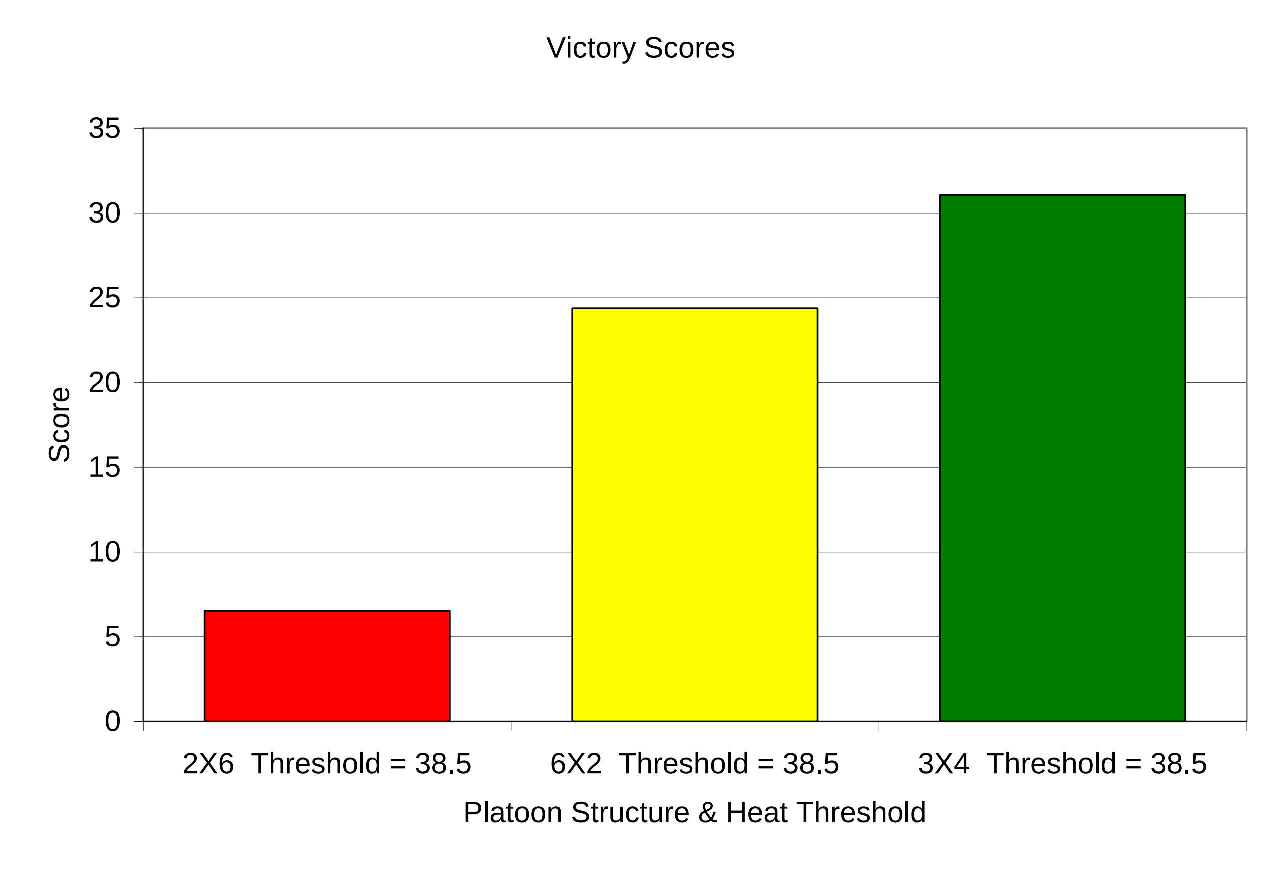


Figure 6: Rank Orders Based on 38.5 Degrees Celsius Heat Stress Threshold Games.

6.3 37.2 Degrees Celsius Heat Stress Threshold Study

The final set of games were run while applying a threshold CBT of 37.2 degrees Celsius before the soldier shut down and became ineffective for the remainder of the game. Figure 7 displays the rank orders derived from this stage of the study. The option rank order shifted again and the three options produced a narrower range of results than the 38.5 threshold. On five occasions heat stress losses were responsible for preventing the 3X4 structured BLUE force from clearing the objective after eliminating all RED forces. The change in order was due to mission outcomes, not heat stress losses. Heat stress was also a factor in preventing BLUE from eliminating all of the RED forces, which in turn prevented BLUE form clearing the objective. The 2X6 option managed to achieve the objective three times allowing it to rank ahead of the 6X2 structure which failed to clear the objective even once. The critical difference between the results of the third stage and those of previous stages was that none of the options studied produced outcomes that would qualify as an acceptable option to recommend as a force structure. While it was possible to rank the options none would have been recommended based on the absolute outcomes of that stage of the study. Within Figure 7 take note of the scale used on the Y axis. The average outcome was a full RED victory. The BLUE force suffered high casualties, both heat and kinetic, rarely cleared the objective and frequently failed to eliminate all of the RED force, leaving them vulnerable to any potential counter-attack on the position they occupied at the end of the fight. One potential bright spot was the generally lower than average number of kinetic casualties, but that was likely due to the high heat stress casualties keeping BLUE soldiers out of the fight. This theory is supported by the fact that the 2X6 structure experienced slightly higher than the overall number of kinetic casualties and also had the lowest average heat stress casualties. While research wargames are generally not used to predict the outcome of a particular battle, such across the board failure is noteworthy when compared to the results observed in stage 1, when no heat penalty was imposed and all options produced at least acceptable outcomes.

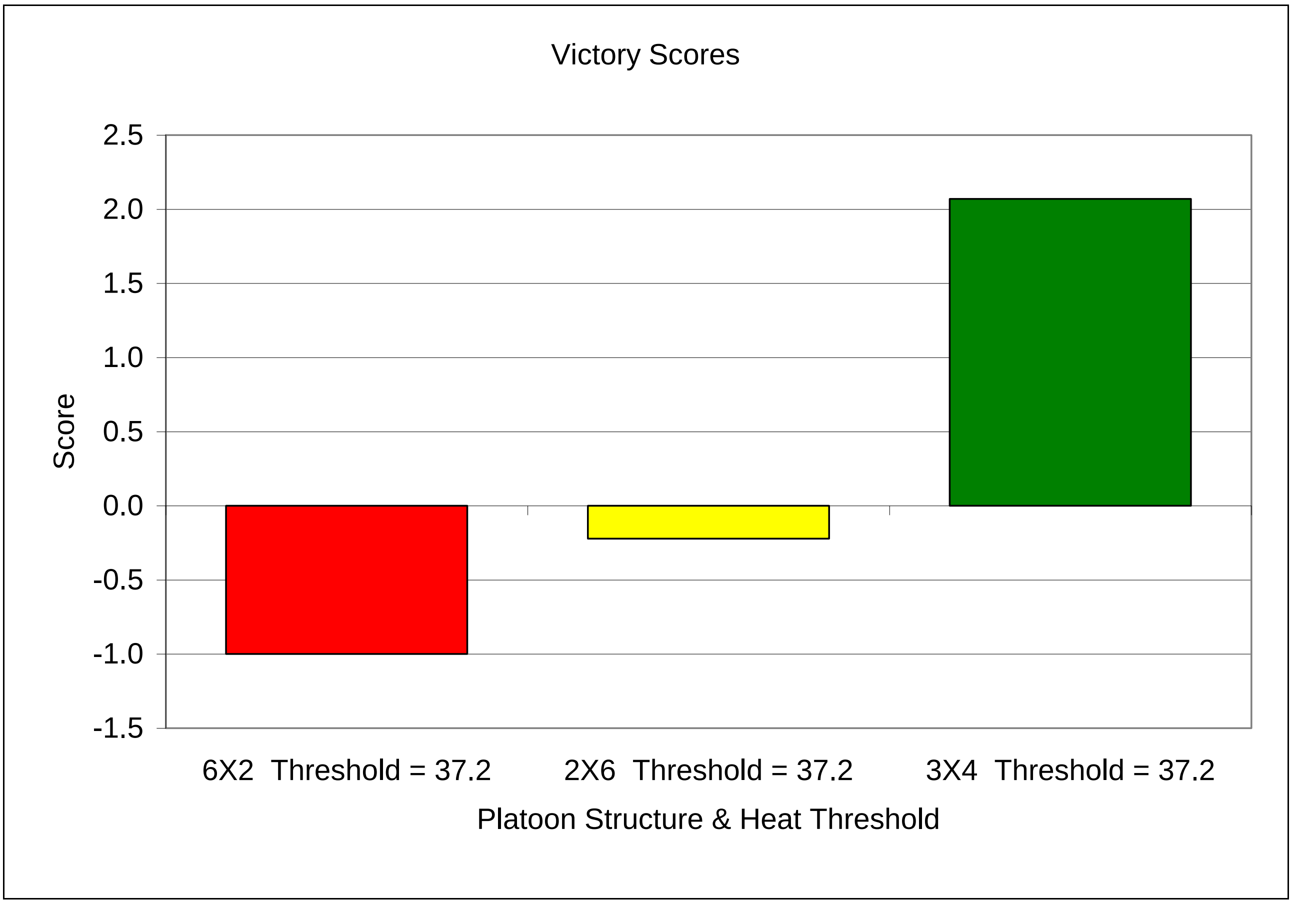


Figure 7: Rank Orders Based on 37.2 Degrees Celsius Heat Stress Threshold Games.

6.4 General Discussion

BLUE losses by cause for each option at each stage are displayed in Table 3. The reason for the significant difference in "Engaged Before HST (Heat Stress Threshold)" between 6X2NH (No HST) and all of the other NH studies is unknown. What is clear from the table's data is the lack of significant losses to heat stress until the CBT threshold was at its lowest. Even at that stage, the option ranks were determined more by the kinetic losses than the heat stress losses. Some BLUE soldiers were eventually engaged after succumbing to heat stress. Those losses did not significantly affect the outcomes of the games. Note that "Engaged After HST" is a subtotal of "Heat Stress Threshold", therefore "Average Total Casualties" is the sum of "Engaged Before HST" and "Heat Stress Threshold".

Table 3: BLUE Losses by Option, Stage and Cause.

Cause of BLUE Loss	Option & Stage								
	2X6 NH	2X6 38.5	2X6 37.2	3X4 NH	3X4 38.5	3X4 37.2	6X2 NH	6X2 38.5	6X2 37.2
Engaged Before HST	4.85	8.24	4.59	4.93	4.37	2.69	0.55	6.00	3.00
Heat Stress Threshold	N/A	0.06	7.30	N/A	0.30	9.21	N/A	0.13	9.00
Engaged After HST	N/A	0.00	1.00	N/A	0.00	0.55	N/A	0.00	0.23
Average Total Casualties	4.85	8.29	11.89	4.93	4.67	11.90	0.55	6.13	12.00

7.0 OTHER OBSERVATIONS

One of the challenges of this exploratory study was to develop an appropriate and realistic core body temperature threshold for a soldier to shut down while in combat. Quite simply there is no data on soldier's core body temperatures while in combat and therefore no linkage to their performance. Combat creates motivation to overcome factors that would cause a soldier to stop any activity under other circumstances. At the same time it creates fear that may cause a solider to shut down before heat stress can become an issue. The difference between these two coping strategies is experience, training, and discipline. The duration of the game and the threshold also interact to allow the heat stress to influence the game or not. The reason for using both 38.5 and 37.2 as shut down thresholds was to explore the implications of using different values. With such stark differences in outcomes over this limited interval of values, further research would be useful to more clearly define the curve.

Another concern for the researchers was the binary nature of the heat stress effect. A soldier either performed at 100% or not at all. Human beings do not behave that way. While any theoretical CBT / performance curve allows for a decline of soldier capabilities, the model used in the game does not incorporate a gradient decline function. The above mentioned ability to overcome otherwise debilitating conditions while in battle may allow a soldier to overcome the early stages of the condition, only to succumb fairly quickly once the condition becomes critical. Thus a motivated soldier's ability may be closer to the binary distribution used in the game. Only further research can shed light on this topic.

Once a soldier succumbed to heat stress, the soldier was out of the fight for the duration of the game. Given the short duration of the battle this may have been reasonable however the choice of threshold, the length of the game and the non-recoverable nature of the heat stress may overstate the effect of it and any further research should be careful to consider this when designing the study.

This study looked at alternate squad sizes, a similar study using the same squad size but variable loads on the soldiers would be of interest as well. The combat model used for the study takes all of the equipment a soldier is carrying into account when calculating heat stress. Factors such as ambient temperature, activity, weight and thermal retention of the equipment are included in the calculation of CBT.

Finally, heat stress penalties were not applied to the RED force. This was in part because it was assumed that the RED force was indigenous to the area, was fully acclimatized and the RED force was not as active as the BLUE force. The RED force was also not carrying as much equipment as the BLUE force.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This study has demonstrated that combat models can simulate the effects of heat stress on soldiers engaged in combat. It has furthermore demonstrated that research wargaming studies which simulate heat stress may well produce different conclusions from research wargaming studies which do not. The study's conclusions can be summarised thus:

- As a field of defence science, research wargaming would benefit from developing the capability to simulate heat stress and other human factors within the combat models used to conduct studies and;
- The employment of such models would improve the quality of research wargaming studies and lead to more informed conclusions and recommendations

The benefits posited by the conclusions do not come without a cost. There remains much work to do to develop this capability either within existing combat models or new ones. The following recommendations if acted upon would lead to the advances necessary to achieve this next step in the evolution of research wargaming. The authors recommend:

- Conducting further studies on a scale of effort similar to this one in order to more fully define the problem space to be researched. Such studies could include:
  - Thresholds between 37.2 and 38.5 degrees Celsius;
  - Variable equipment loads;
  - Longer duration activities;
  - Variable climates and;
  - Heat stress applied to RED (opposing) forces as well.
- That combat model developers work with human factors researchers to incorporate the most realistic algorithms possible into the combat models and;
- Conducting further research into human factors to close the gaps in the knowledge about the relationship between soldier loads and combat performance.

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ANNEX A GAME OUTCOMES

Note that BLUE kinetic and heat losses may sum to more than 12 due to some soldiers gettting shot after sufferiing heat stress. BLUE RCS is calculated based on total losses form either cause, net the soldiers shot after suffering heat stress.

Table A1: Game Outcomes.

	Kinetic Losses		Heat			RCS		
BLUE Force	RED	BLUE	Threshold	BLUE Losses	Outcome	BLUE	RED	VP Score
2X6	6	7	None	0	Blue win	42%	0%	27
2X6	6	1	None	0	Blue win	92%	0%	37
2X6	6	6	None	0	Blue win	50%	0%	27
2X6	6	6	None	0	Blue win	50%	0%	27
2X6	6	3	None	0	Blue win	75%	0%	37
2X6	6	5	None	0	Blue win	58%	0%	27
2X6	6	4	None	0	Blue win	67%	0%	37
2X6	6	2	None	0	Blue win	83%	0%	37
2X6	6	5	None	0	Blue win	58%	0%	27
2X6	6	6	None	0	Red win	50%	0%	10
2X6	6	1	None	0	Blue win	92%	0%	37
2X6	6	8	None	0	Red win	33%	0%	3
2X6	6	6	None	0	Blue win	50%	0%	27
2X6	6	6	None	0	Blue win	50%	0%	27
2X6	6	3	None	0	Blue win	75%	0%	37
2X6	6	7	None	0	Blue win	42%	0%	27
2X6	6	7	None	0	Red win	42%	0%	10
2X6	6	5	None	0	Blue win	58%	0%	27
2X6	6	5	None	0	Blue win	58%	0%	27
2X6	6	6	None	0	Blue win	50%	0%	27
2X6	6	4	None	0	Blue win	67%	0%	37
2X6	6	4	None	0	Blue win	67%	0%	37
2X6	6	5	None	0	Blue win	58%	0%	27
2X6	6	4	None	0	Blue win	67%	0%	37
2X6	6	8	None	0	Red win	33%	0%	3
2X6	6	2	None	0	Blue win	83%	0%	37
2X6	6	5	None	0	Blue win	58%	0%	27
3X4	6	5	None	0	Blue win	58%	0%	27
3X4	6	6	None	0	Blue win	50%	0%	27
3X4	6	3	None	0	Blue win	75%	0%	37
3X4	6	5	None	0	Blue win	58%	0%	27
3X4	6	3	None	0	Blue win	75%	0%	37
3X4	6	8	None	0	Red win	33%	0%	3
3X4	6	5	None	0	Blue win	58%	0%	27
3X4	6	7	None	0	Red win	42%	0%	10
3X4	6	8	None	0	Blue win	33%	0%	18
3X4	6	5	None	0	Blue win	58%	0%	27
3X4	6	3	None	0	Blue win	75%	0%	37
3X4	6	8	None	0	Blue win	33%	0%	18

	Kinetic Losses		Heat			RCS		
BLUE Force	RED	BLUE	Threshold	BLUE Losses	Outcome	BLUE	RED	VP Score
3X4	6	7	None	0	Blue win	42%	0%	27
3X4	6	6	None	0	Blue win	50%	0%	27
3X4	6	4	None	0	Blue win	67%	0%	37
3X4	6	6	None	0	Blue win	50%	0%	27
3X4	6	1	None	0	Blue win	92%	0%	37
3X4	5	8	None	0	Red win	33%	17%	3
3X4	6	6	None	0	Blue win	50%	0%	27
3X4	6	7	None	0	Blue win	42%	0%	27
3X4	6	5	None	0	Blue win	58%	0%	27
3X4	6	4	None	0	Blue win	67%	0%	37
3X4	6	4	None	0	Blue win	67%	0%	37
3X4	6	4	None	0	Blue win	67%	0%	37
3X4	6	3	None	0	Blue win	75%	0%	37
3X4	6	5	None	0	Blue win	58%	0%	27
3X4	6	1	None	0	Blue win	92%	0%	37
3X4	6	0	None	0	Blue win	100%	0%	37
3X4	5	6	None	0	Red win	50%	17%	9
6X2	6	0	None	0	Blue win	100%	0%	37
6X2	6	0	None	0	Blue win	100%	0%	37
6X2	6	1	None	0	Blue win	92%	0%	37
6X2	6	1	None	0	Blue win	92%	0%	37
6X2	6	0	None	0	Blue win	100%	0%	37
6X2	6	2	None	0	Blue win	83%	0%	37
6X2	6	0	None	0	Blue win	100%	0%	37
6X2	6	1	None	0	Blue win	92%	0%	37
6X2	6	0	None	0	Blue win	100%	0%	37
6X2	6	0	None	0	Blue win	100%	0%	37
6X2	6	1	None	0	Blue win	92%	0%	37
2X6	4	11	38.5	0	Red win	8%	33%	3
2X6	4	9	38.5	1	Red win	17%	33%	3
2X6	4	8	38.5	0	Red win	33%	33%	3
2X6	6	7	38.5	0	Red win	42%	0%	10
2X6	3	9	38.5	0	Red win	25%	50%	2
2X6	3	7	38.5	0	Red win	42%	50%	7
2X6	3	7	38.5	0	Red win	42%	50%	7
2X6	5	7	38.5	0	Red win	42%	17%	9
2X6	6	7	38.5	0	Red win	42%	0%	10
2X6	3	8	38.5	0	Red win	33%	50%	2
2X6	3	7	38.5	0	Red win	42%	50%	7
2X6	6	10	38.5	0	Blue win	17%	0%	18
2X6	4	6	38.5	0	Red win	50%	33%	9
2X6	6	9	38.5	0	Blue win	25%	0%	18
2X6	4	10	38.5	0	Red win	17%	33%	3
2X6	2	9	38.5	0	Red win	25%	67%	0
2X6	2	9	38.5	0	Red win	25%	67%	0
3X4	6	5	38.5	0	Blue win	58%	0%	27

	Kinetic Losses		Heat			RCS		
BLUE Force	RED	BLUE	Threshold	BLUE Losses	Outcome	BLUE	RED	VP Score
3X4	6	2	38.5	1	Blue win	75%	0%	37
3X4	6	3	38.5	0	Blue win	75%	0%	37
3X4	6	4	38.5	0	Blue win	67%	0%	37
3X4	6	5	38.5	0	Blue win	58%	0%	27
3X4	5	9	38.5	0	Red win	25%	17%	3
3X4	6	3	38.5	0	Blue win	75%	0%	37
3X4	6	3	38.5	1	Blue win	67%	0%	37
3X4	6	7	38.5	0	Blue win	42%	0%	27
3X4	6	4	38.5	0	Blue win	67%	0%	37
3X4	6	3	38.5	1	Blue win	67%	0%	37
3X4	6	4	38.5	1	Blue win	58%	0%	27
3X4	6	6	38.5	0	Blue win	50%	0%	27
6X2	6	6	38.5	0	Blue win	50%	0%	27
6X2	6	6	38.5	0	Red win	50%	0%	10
6X2	6	7	38.5	0	Blue win	42%	0%	27
6X2	6	6	38.5	0	Blue win	50%	0%	27
6X2	6	6	38.5	0	Blue win	50%	0%	27
6X2	6	4	38.5	0	Blue win	67%	0%	37
6X2	6	4	38.5	0	Blue win	67%	0%	37
6X2	4	9	38.5	1	Red win	17%	33%	3
2X6	4	3	37.2	10	Red win	0%	33%	-1
2X6	2	4	37.2	9	Red win	0%	67%	-3
2X6	4	8	37.2	5	Red win	0%	33%	-1
2X6	4	4	37.2	11	Red win	0%	33%	-1
2X6	4	4	37.2	8	Red win	0%	33%	-1
2X6	2	5	37.2	7	Red win	0%	67%	-3
2X6	4	5	37.2	7	Red win	0%	33%	-1
2X6	2	6	37.2	7	Red win	0%	67%	-3
2X6	4	5	37.2	7	Red win	0%	33%	-1
2X6	4	6	37.2	5	Red win	8%	33%	3
2X6	4	6	37.2	5	Red win	8%	33%	3
2X6	6	5	37.2	11	Blue win	0%	0%	10
2X6	2	4	37.2	9	Red win	0%	67%	-3
2X6	3	5	37.2	7	Red win	0%	50%	-2
2X6	2	6	37.2	6	Red win	0%	67%	-3
2X6	2	7	37.2	5	Red win	0%	67%	-3
2X6	3	6	37.2	7	Red win	0%	50%	-2
2X6	4	11	37.2	4	Blue win	0%	33%	9
2X6	2	6	37.2	7	Red win	0%	67%	-3
2X6	2	4	37.2	7	Red win	8%	67%	0
2X6	4	7	37.2	5	Red win	0%	33%	-1
2X6	4	10	37.2	8	Blue win	0%	33%	9
2X6	3	8	37.2	7	Red win	0%	50%	-2
2X6	5	6	37.2	6	Red win	0%	17%	-1
2X6	5	4	37.2	8	Red win	0%	17%	-1
2X6	4	2	37.2	11	Red win	0%	33%	-1

	Kinetic Losses		Heat			RCS		
BLUE Force	RED	BLUE	Threshold	BLUE Losses	Outcome	BLUE	RED	VP Score
2X6	2	4	37.2	8	Red win	0%	67%	-3
3X4	4	2	37.2	10	Red win	0%	33%	-1
3X4	6	3	37.2	9	Red win	0%	0%	-1
3X4	4	3	37.2	9	Red win	0%	33%	-1
3X4	6	4	37.2	9	Blue win	0%	0%	10
3X4	6	2	37.2	11	Blue win	0%	0%	10
3X4	5	1	37.2	11	Red win	0%	17%	-1
3X4	4	4	37.2	8	Red win	0%	33%	-1
3X4	4	2	37.2	10	Red win	0%	33%	-1
3X4	5	4	37.2	8	Red win	0%	17%	-1
3X4	5	1	37.2	11	Red win	0%	17%	-1
3X4	6	6	37.2	7	Blue win	0%	0%	10
3X4	6	2	37.2	11	Red win	0%	0%	-1
3X4	6	5	37.2	7	Red win	0%	0%	-1
3X4	5	5	37.2	9	Red win	0%	17%	-1
3X4	6	3	37.2	10	Blue win	0%	0%	10
3X4	6	3	37.2	10	Red win	0%	0%	-1
3X4	4	1	37.2	11	Red win	0%	33%	-1
3X4	5	4	37.2	10	Red win	0%	17%	-1
3X4	6	2	37.2	8	Blue win	17%	0%	18
3X4	4	4	37.2	8	Red win	0%	33%	-1
3X4	5	3	37.2	8	Red win	8%	17%	3
3X4	4	2	37.2	10	Red win	0%	33%	-1
3X4	4	3	37.2	9	Red win	0%	33%	-1
3X4	6	6	37.2	9	Blue win	0%	0%	10
3X4	6	3	37.2	9	Blue win	0%	0%	10
3X4	5	3	37.2	9	Red win	0%	17%	-1
3X4	5	4	37.2	8	Red win	0%	17%	-1
3X4	4	4	37.2	8	Red win	0%	33%	-1
3X4	6	5	37.2	10	Red win	0%	0%	-1
6X2	5	5	37.2	7	Red win	0%	17%	-1
6X2	5	3	37.2	10	Red win	0%	17%	-1
6X2	4	2	37.2	10	Red win	0%	33%	-1
6X2	4	3	37.2	10	Red win	0%	33%	-1
6X2	4	5	37.2	8	Red win	0%	33%	-1
6X2	4	2	37.2	10	Red win	0%	33%	-1
6X2	4	4	37.2	8	Red win	0%	33%	-1
6X2	4	2	37.2	10	Red win	0%	33%	-1
6X2	5	2	37.2	10	Red win	0%	17%	-1
6X2	4	3	37.2	9	Red win	0%	33%	-1
6X2	4	6	37.2	6	Red win	0%	33%	-1
6X2	5	2	37.2	10	Red win	0%	17%	-1
6X2	5	3	37.2	9	Red win	0%	17%	-1